# The Epidemiology of Respiratory Distress Syndrome in Neonates in Fiji: A Retrospective Cohort Study

Joshua Szanyi, Ilisapeci Tuibeqa, Tupou Ratu, Kate Milner, Cattram D Nguyen, Evelyn Tuivaga, Fiona M Russell

**Abstract**

*Introduction* The commonest cause of death in preterm newborns worldwide is respiratory distress syndrome (RDS). In Fiji, prematurity and RDS have been identified as important causes of neonatal mortality but no studies to date have investigated RDS epidemiology in this setting. Surfactant replacement therapy (SRT; a highly effective RDS treatment) has been used in high-income countries for many years, but was only recently added to supportive care in Fiji in 2015, and requires justification for its ongoing use given its high cost. This retrospective cohort study describes the RDS epidemiology in Fiji's major neonatal centre prior to SRT introduction and highlights areas to be addressed to improve newborn care in the country.

*Methods* RDS-related intensive care admissions at Colonial War Memorial Hospital in 2013 and 2014 were reviewed and clinical information was extracted from medical records. This data was used to ascertain the rate of RDS at the hospital, the rate of death among newborns with RDS, and factors associated with survival to discharge from hospital.

*Results* The rate of RDS was 6.7 (95% confidence interval 5.5 – 8.0) per 1,000 live births. There were 36 deaths among neonates with RDS in the study period. There were no significant differences between newborns who survived and those who died with respect to demographic characteristics such as sex or ethnicity. No neonates who died received more than one dose of corticosteroids, compared to 25.3% of survivors.

*Conclusion* Death of newborns from RDS was high, and is consistent with that in other low- and middle-income countries prior to the uptake of surfactant therapy. Improving antenatal corticosteroid use and providing ongoing access to SRT, which are well-established therapies for RDS prevention and treatment, are likely to improve outcomes for newborns in Fiji.

**Keywords:** low- and middle-income, neonate, respiratory distress syndrome

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## Introduction

Complications of prematurity are the leading causes of neonatal deaths worldwide (Lawn et al., 2013). Every year 15 million newborns are born preterm and over one million are expected to die from complications (Lawn et al., 2013). Most of these births occur in low- and middle-income countries (LMICs) (Lawn et al., 2013; Vidyasagar, Velaphi, & Bhat, 2011). In particular, respiratory distress syndrome (RDS), due to surfactant deficiency, is a major cause of mortality among preterm newborns globally (Pickerd & Kotecha, 2009; Vidyasagar et al., 2011).

It is important to understand the burden of RDS in LMICs and describe clinical management in order to monitor clinical outcomes and inform quality of care improvement (Kamath, Macguire, McClure, Goldenberg, & Jobe, 2011). However, the epidemiology and clinical care of RDS in LMICs is currently poorly understood due to the lack of high-quality RDS data from these regions (Vidyasagar et al., 2011).

In Fiji, prematurity and its complications have been highlighted as the nation's greatest contributor to neonatal deaths (Bythell et al., 2014). However, no published studies to date have specifically addressed the burden of RDS in Fijian neonates. This is of particular relevance as surfactant replacement therapy (SRT), a highly effective RDS treatment used in high-income settings for over three decades, was recently introduced into neonatal care in Fiji in 2015. SRT is known to reduce mortality, improve oxygenation and reduce the risk of complications in neonates with RDS (Engle & American Academy of Pediatrics Committee on Fetus and Newborn, 2008). However, it is very costly. Hence it is important to provide the evidence for non-medical decision makers on procurement on the value of this costly medication in this setting. In addition, antenatal corticosteroids administered to mothers in preterm labour are known to reduce the risk of newborns developing RDS and reduce the severity of the disease, however it is not known how many mothers of newborns with RDS in Fiji have been treated with antenatal corticosteroids. The aim of this study was therefore to answer the following research questions: 1) what was the baseline epidemiology of Fijian newborns with RDS prior to the introduction of SRT?; and 2) in order to inform health professionals in Fiji regarding areas of potential improvement in neonatal care in the country, what factors are associated with inpatient death of newborns with RDS?

## Methods

### *Study design and setting*

This retrospective cohort study was undertaken in Fiji, an upper middle-income country with a neonatal mortality rate of 7.7 per 1,000 live births (Fiji Ministry of Health and Medical Services, 2014). The Colonial War Memorial Hospital (CWMH) in Suva is Fiji's main tertiary referral hospital and the main neonatal referral centre. This study was

undertaken in the Paediatrics Department at CWMH. There were 17,058 live births at CWHM and 1519 neonatal intensive care (NICU) admissions during the study period.

Local obstetric guidelines recommend antenatal corticosteroid administration to mothers in labour at <34 weeks' gestation for RDS prevention. All babies born at the hospital have a gestational age assessment performed using the postnatal Ballard scoring system (Ballard et al., 1991), which provides an estimated gestational age. SRT was not available at CWMH during the study period.

*Study population*

A case of RDS was defined as any newborn born in 2013 or 2014, admitted to the NICU or Paediatric Intensive Care Unit (PICU) at CWMH, with a clinical diagnosis of RDS made at the time of admission as the primary cause for admission or as a comorbidity. Exclusion criteria included the presence of an alternative diagnosis for respiratory distress as determined by the attending paediatrician.

*Data collection*

Newborns potentially meeting the above criteria were identified by searching intensive care admissions registers from 2013 and 2014 for 1) the terms "respiratory distress syndrome", "hyaline membrane disease", "RDS" or "HMD" as admission diagnoses or discharge classifications, and 2) all admissions with gestational age less than 36 weeks or birth weight less than 2500 grams. In addition, to ensure all cases and deaths were captured, the neonatal deaths register and all files in the medical records department for children who died during 2013-2015 were reviewed for RDS as a cause of death or clinical diagnosis during their admission.

Medical records of these newborns were then reviewed to determine whether they met the inclusion criteria. For those fitting the case definition, the following data were extracted and recorded on data collection forms: demographics, antenatal and delivery history, clinical findings, treatment, the development of any complications, outcomes at hospital discharge, and, if available, outcome at 28 days and one year of life. Following their initial admission any outpatient visits or readmissions were also recorded. Gestational ages of newborns were recorded based on postnatal Ballard score if recorded in the medical record. If a Ballard score was not recorded, gestational age was determined by the date of the last menstrual period, or if this was not available, any other method recorded in the medical record including ultrasound. Maternal medical records were not available for review. These data were entered into an EpiData (EpiData Association, version 2.0.8.56) database.

*Statistical methods*

Data were analysed using Stata (StataCorp. 2015. *Stata Statistical Software:* Release 14. College Station, TX: StataCorp LP). Categorical variables including demographic, clinical and outcome characteristics were summarised as percentages. Continuous variables were summarised using means and standard deviations if symmetric and medians and interquartile ranges if non-symmetric. Survivors to hospital discharge and those who died as inpatients were compared using Chi-square tests for categorical variables, unless the expected cell sizes in a contingency table were <5, in which case Fisher's exact test was used. Univariate logistic regression analyses were performed to generate odds ratios and 95% confidence intervals for variables associated with survival or inpatient death. Due to issues with sample size and perfect prediction it was not possible to analyse the data with a multivariate model. The rate of RDS and the number of RDS deaths per 1000 live births were calculated using the number of RDS cases born at CWMH during the two year study period and the total number of live births at CWMH over the same time period as the denominator. Statistical significance was defined as a p value <0.05.

*Ethics*

The study was approved by The University of Melbourne Health Sciences Human Ethics Sub-Committee (Ethics ID 1545160.1) and the Fiji National Research Ethics Review Committee (FNRERC number 2014.79.C.D) prior to study commencement.

## Results

Figure 1 outlines the process by which newborns diagnosed with RDS were identified. There were 512 newborns identified initially. Of these, 336 (65.6%) medical records could be located, with 127 of these newborns meeting the case definition. The RDS rate among newborns at CWMH (that is, excluding babies born at other hospitals) was at least 6.7 per 1000 live births (95% confidence interval (CI) 5.5 – 8.0 per 1000 live births).

Table 1 summarises the demographics, clinical characteristics and management of the newborns with RDS. No statistically significant differences were found between survivors to hospital discharge and non-survivors with respect to demographic characteristics including sex (p=0.783) or ethnicity (iTaukei, p=0.521; Fijian of Indian Descent, p=0.263; Other, p=0.417). Increased one minute and five minute Apgar scores were positively associated with survival to hospital discharge (odds ratio (OR) 1.72, 95% CI 1.31 – 2.25, p<0.01 and OR 1.97, 95% CI 1.40 – 2.76, p<0.01 respectively, see Table 2). Survival to discharge was positively associated with increasing birth weight per 100 grams (OR 1.26, 95% CI 1.13 – 1.41, p<0.01) and with increasing gestational age in weeks (OR 1.63, 95% CI 1.34 – 1.98, p<0.01). Non-survivors were

significantly less likely to be delivered by mothers who had received more than one dose of antenatal corticosteroids compared with survivors (0% v. 25.3%, p=<0.001). In total, 36.2% of cases had a record of maternal antenatal steroid administration while in labour. Of those less than 34 weeks gestation, 40.8% received antenatal corticosteroids. Increasing doses of antenatal corticosteroids were associated with an odds ratio for inpatient survival of 2.1 (95% CI 0.97 – 4.48, p=0.06).

Table 3 summarises the inpatient complications of the newborns diagnosed with RDS during the study period. Including those who died whilst in hospital, 91.3% had at least one complication. There were 36 deaths among newborns with RDS at CWMH during the study period. 28 of these were babies born at CWMH giving an RDS death rate of at least 1.6 per 1000 live births (95% CI 1.0 – 2.2 per 1000 live births). Figure 2 summarises the number of newborns affected by RDS categorised by gestational age and birthweight including the proportion of cases in each group who died as inpatients.

Of the 91 babies discharged alive from hospital, 63.7% did not return to attend the routine neonatal follow-up clinic. Almost half (48.4%) were not treated or reviewed again in the outpatients department at CWMH for any reason. The median number of total outpatient visits for survivors to hospital discharge for any presentation was one (IQR 0 – 3). The majority (78.0%) of survivors to discharge were not readmitted to CWMH within their first 12 months of life.

**Discussion**

This study is the first in Fiji to document RDS epidemiology and mortality, finding an RDS rate of at least 6.7 per 1,000 live births. This rate is comparable to that reported from many other LMICs, which range from 0.62% of live births in an Indian study (Kumar & Bhat, 1996) to 1.72% in a Pakistani study (Ghafoor, Mahmud, Ali, & Dogar, 2003). We also found that only a small proportion of women received antenatal steroids, and follow up of high risk newborns following discharge was very low. These findings provide guidance on how to improve the quality of perinatal care for premature newborns, and also provide a baseline to monitor outcomes following the introduction of SRT in 2015 in addition to providing justification for ongoing access to SRT.

Although RDS is acknowledged as the greatest contributor to neonatal mortality in preterm newborns worldwide (Vidyasagar et al., 2011), a number of factors have meant that ascertaining RDS incidence in low-resource settings has historically been challenging. These include lack of access to healthcare, diagnostic uncertainty, a lack of documentation of cases and selection bias (Ghafoor et al., 2003; Kamath et al., 2011). Other studies investigating the RDS rate in LMICs have generally been conducted prospectively (Ghafoor et al., 2003; Kumar & Bhat, 1996; Mlay & Manji, 2000) with clear case definitions. In contrast, strict inclusion criteria within which to identify RDS cases could not be

applied in our study due to its retrospective nature and the lack of detailed information contained within the medical records. As such, inclusion relied upon a diagnosis of RDS made by a paediatrician at the time of admission, which may have been subject to variability, particular given the fact that RDS can be difficult to differentiate from other causes of respiratory distress in the neonate (Kamath et al., 2011). Moreover, the rate we found in our study is likely to be an underestimate as we were not able to locate about one-third of the medical records to confirm eligibility.

This study found a high rate of RDS deaths of 1.6 per 1000 live births at the study site. There have been drastic improvements in the RDS-specific mortality rate observed in high-income settings since the 1950s, attributed to the sequential implementation of oxygen therapy, continuous positive airway pressure, mechanical ventilation, antenatal corticosteroids and SRT (Kamath et al., 2011). The result of these improvements in neonatal care is that now very few newborns who develop RDS in high-income settings die of the condition (Kamath et al., 2011). However, the utilisation of these technologies in LMICs varies substantially (Kamath et al., 2011). SRT was not available at the time of this study, and many mothers in preterm labour at the study site were not treated with antenatal corticosteroids.

Numerous meta-analyses have concluded that antenatal corticosteroids administered to women in preterm labour reduce the risk of newborns developing RDS (relative risk (RR) 0.66, 95% CI 0.59 – 0.73), reduce neonatal deaths by 31% (RR 0.69, 95% CI 0.58 – 0.81), and reduce intensive care admissions by 20% (RR 0.80, 95% CI 0.65 – 0.99) (Roberts & Dalziel, 2006). The protective effects of antenatal corticosteroids have been demonstrated to be more pronounced in middle-income countries than in high-income countries, with a mortality reduction of 53% (RR 0.47, 95% CI 0.35 – 0.64) calculated in a middle-income country-specific meta-analysis (Mwansa-Kambafwile, Cousens, Hansen, & Lawn, 2010). As a result, increased uptake of this therapy has been recommended in LMICs (Mwansa-Kambafwile et al., 2010). Despite antenatal corticosteroids being available in Fiji for mothers in preterm labour, a record of their administration was only observed in slightly over one third of RDS cases. Importantly, none of the newborns who died as inpatients were born to mothers who received more than one dose of antenatal steroids, compared to 25.3% of survivors. Of those with gestational ages of <34 weeks, only 40.8% had records confirming administration of antenatal corticosteroids. However, maternal records were not available for review, so the true rate of antenatal steroid administration may be higher than that reported here. Nevertheless, the low rates of antenatal corticosteroid use observed in this study are likely to represent an unmet need for this treatment in Fiji.

In addition, endotracheal SRT has been used to treat RDS in high-income countries since the first successful trial of the intervention was reported in 1980 (Fujiwara et al., 1980). Meta-analyses have

subsequently confirmed its efficacy in reducing RDS-specific mortality by up to 40% (RR 0.60, 95% CI 0.47 - 0.77) (Polin, Carlo, & American Academy of Pediatrics Committee on Fetus and Newborn, 2014). Historically, however, the feasibility of introducing SRT in LMICs has been limited due to a lack of appropriately trained clinical staff to deliver the treatment, a lack of equipment and laboratory support to facilitate care of the neonate during and following treatment, and the high cost of surfactant preparations (Vidyasagar et al., 2011). Prior to 2015, SRT was not available in Fiji and as such the newborns included in the present study did not have access to this therapy. SRT is now being used in neonatal care at CWMH for neonates with ages of gestation between 28 weeks and 34 completed weeks by Ballard score who are diagnosed with RDS. This recent addition to NICU care may improve outcomes for preterm infants in Fiji if it continues to be made available.

This study was subject to limitations that affect all retrospective studies, including the influence of incomplete data, and the inability to locate 34.4% of the medical records. It is not known whether any newborns discharged alive subsequently died at home. Many babies were not reviewed in the outpatient setting, limiting analysis of longer-term outcomes of cases and highlighting the need for follow-up of cases once discharged from hospital. Finally, a lack of access to maternal health records due to health information systems issues at CWMH prevented cross-referencing of information related to pregnancy and delivery between maternal and neonatal records. As such it is difficult to determine whether rates of pregnancy complications and treatment administered to mothers, including antenatal corticosteroids, were higher than those reported in this study where the only source of information was the neonatal medical record.

## Conclusion

This is the first study to document the epidemiology of RDS in Fiji. It provides important information regarding the incidence of RDS, and provides a baseline to monitor improvements in perinatal care. Moreover, the study highlights the high mortality rate in newborns who develop RDS, which has the potential to be improved following the introduction and continued use of SRT along with addressing the barriers association with antenatal corticosteroid administration. This is linked closely with improving the continuum of care between obstetric and neonatal services. As mortality improves, it will be important to focus on the overall quality of neonatal care and strengthen follow-up of this group of babies who are at high risk of neurodevelopmental morbidity. These results form the basis of an economic evaluation of RDS at CWMH, and importantly provide a foundation for advocating for improved prevention and care for neonates with RDS in Fiji including the continued use of SRT in this cohort.

**Acknowledgments**

The authors wish to thank the staff at the Colonial War Memorial Hospital in Suva, Fiji, for their kind assistance during the data collection process, and staff at the Centre for International Child Health for their assistance with preparation of the manuscript. Financial support during the data collection process was provided by the St. Vincent's Pacific Health Fund Andrew Dent Scholarship and the University of Melbourne Global Scholars Award.

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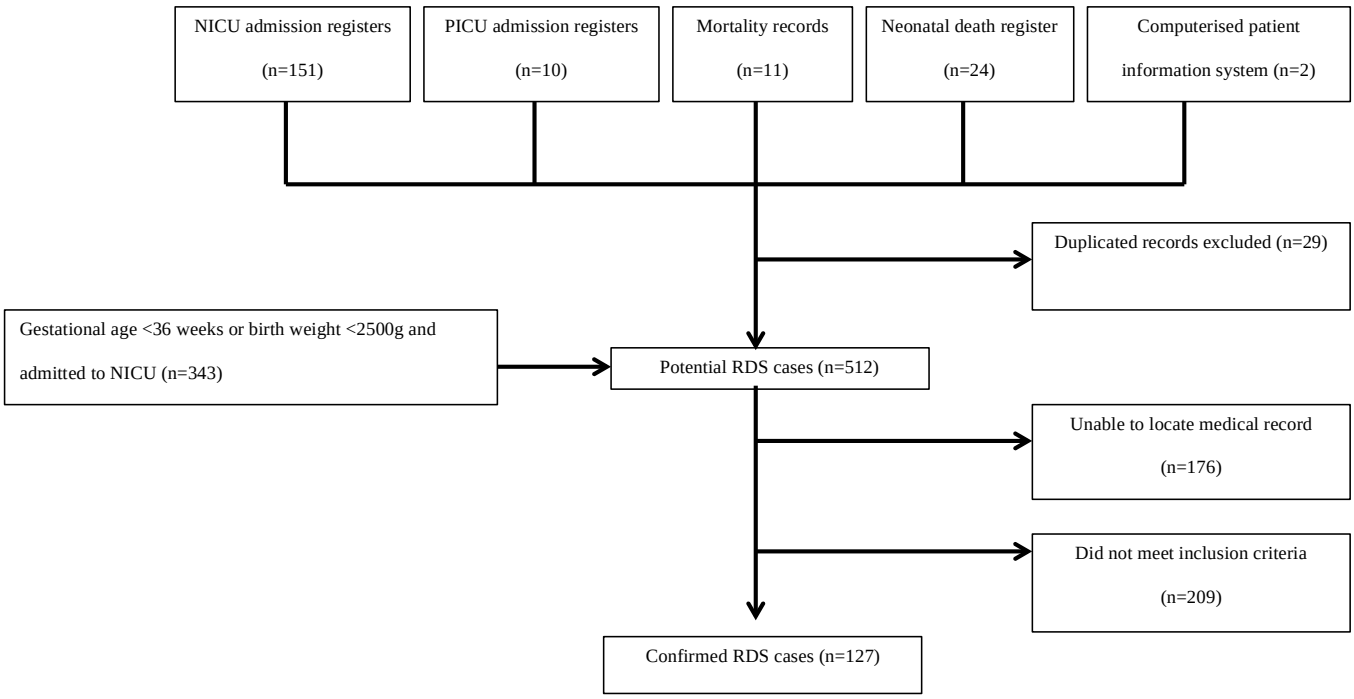
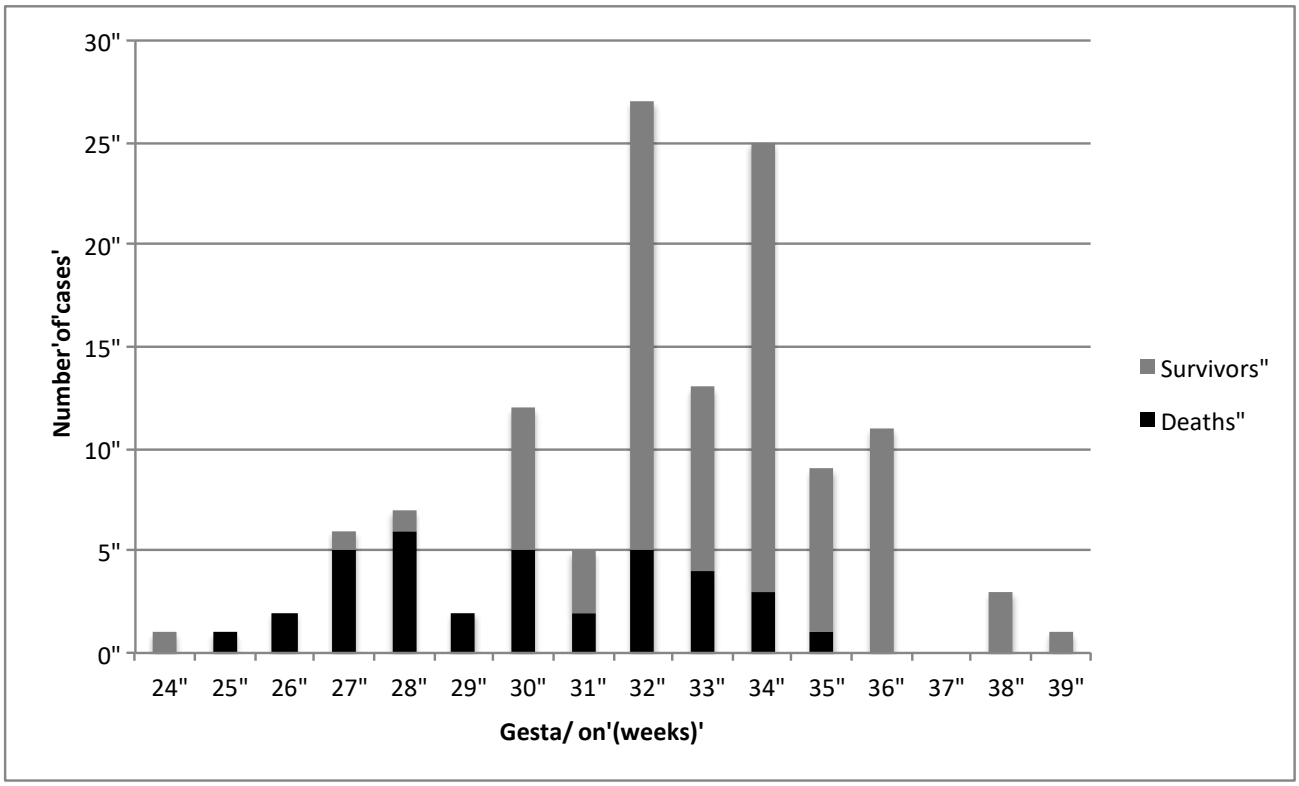
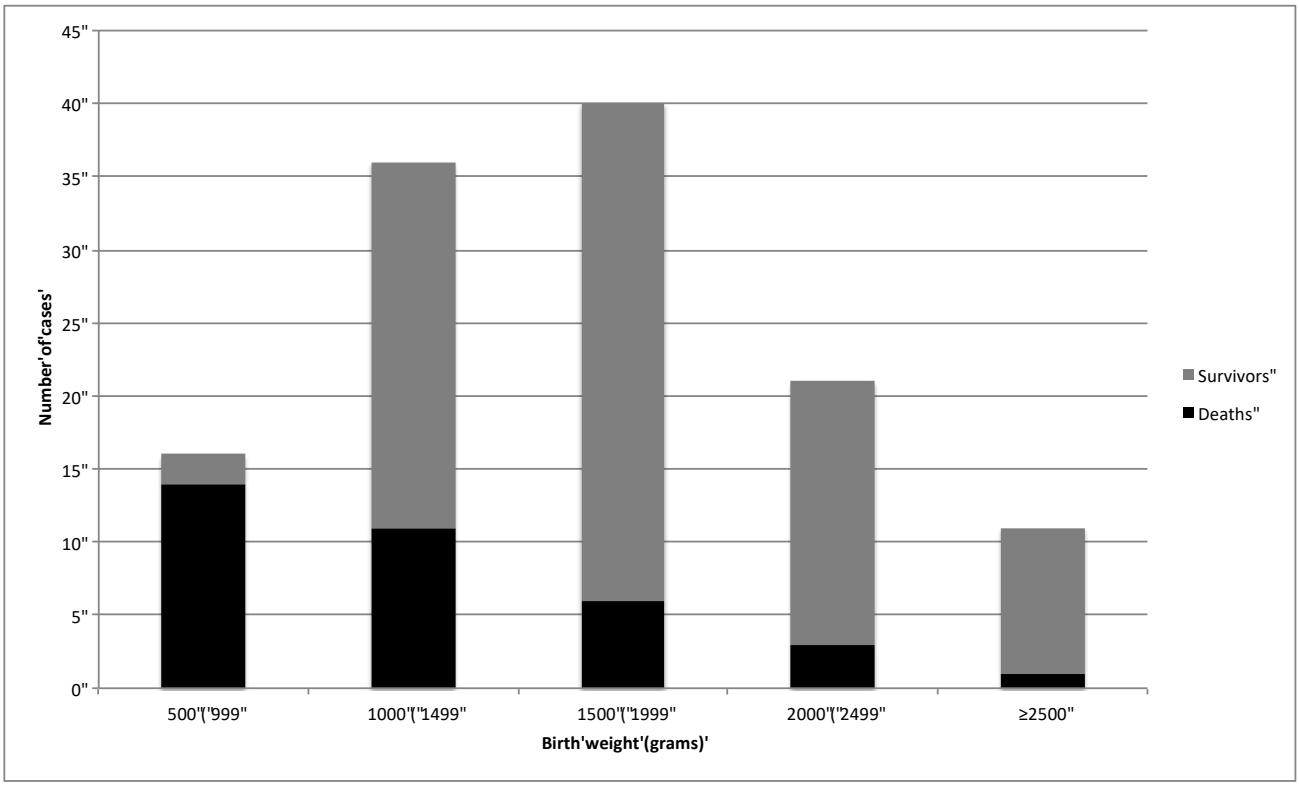



**Figure 1** Flowchart for identifying Respiratory Distress Syndrome cases at the Colonial War Memorial Hospital, Suva, 2013-2014




(a)




(b)

**Figure 2** (a & b) Number of respiratory distress syndrome cases at the Colonial War Memorial Hospital in 2013 and 2014, by gestational age (a) and birth weight (b).

**Table 1** Demographic and clinical characteristics of neonates diagnosed with respiratory distress syndrome at Colonial War Memorial Hospital, Suva in 2013-2014 (n=127)

| Characteristics | RDS cases (n=127) |
|---|---|
| ***Demographics*** | |
| **Place of birth** | |
| **In-born, n (%)** | 114 (89.8) |
| **Not recorded, n (%)** | 7 (5.5) |
| **Sex** | |
| **Male, n (%)** | 69 (54.3) |
| **Not recorded, n (%)** | 9 (7.1) |
| **Ethnicity** | |
| **iTaukei, n (%)** | 65 (51.2) |
| **Fijian of Indian Descent, n (%)** | 42 (33.1) |
| **Other, n (%)** | 9 (7.1) |
| **Not recorded, n (%)** | 11 (8.7) |
| ***Pregnancy and delivery*** | |
| **One minute Apgar, median (IQR)** | 7 (5 - 8) |
| **Five minute Apgar, median (IQR)** | 8 (7 - 9) |
| **Gestational age[1] in weeks, median (IQR)** | 32 (31 – 34) |
| **Birth weight in grams, median (IQR)** | 1575 (1250 – 2000) |
| **Caesarean section, n (%)** | 69 (54.3) |
| **Not recorded, n (%)** | 5 (3.9) |
| **Twin pregnancy, n (%)** | 26 (20.5) |
| **Prolonged rupture of membranes, n (%)** | 18 (14.2) |
| **Not recorded, n (%)** | 27 (21.3) |
| **Gestational diabetes, n (%)** | 12 (9.5) |
| **Not recorded, n (%)** | 22 (17.3) |
| ***Clinical features on admission to NICU*** | |
| **Hypothermia[2], n (%)** | 71 (55.9) |
| **Not recorded, n (%)** | 42 (33.1) |
| **Hypoglycaemia[3], n (%)** | 22 (17.3) |
| **Not recorded, n (%)** | 24 (18.9) |
| **Acidosis[4], n (%)** | 36 (28.4) |
| **Not recorded, n (%)** | 82 (64.6) |
| ***Management*** | |
| **Supplemental oxygen, n (%)** | 122 (96.1) |
| **Not recorded, n (%)** | 5 (3.9) |
| **CPAP, n (%)** | 95 (74.8) |
| **Not recorded, n (%)** | 4 (3.2) |
| **Mechanical ventilation, n (%)** | 54 (42.5) |
| **Not recorded, n (%)** | 7 (5.5) |
| **Length of stay in days, median (IQR)** | 17 (6 – 34) |

| | |
|---|---|
| **Length of NICU admission in days, median (IQR)** | 11 (4 – 22) |
| **Duration of supplemental oxygen in days (median, IQR)** | 3.0 (1.2 – 6.6) |
| **Duration of CPAP in days, median (IQR)** | 1.5 (0.80 – 3.7) |
| **Duration of mechanical ventilation in days, median (IQR)** | 3.1 (1.4 – 8.2) |
| **Antenatal corticosteroids administered** | |
| **Yes, n (%)** | 46 (36.2) |
| **Not recorded, n (%)** | 55 (43.3) |
| **Number of antenatal steroid doses recorded (if steroids administered)** | |
| **1 dose, n (%)** | 16 (12.6) |
| **>1 dose, n (%)** | 23 (18.1) |
| **Not recorded, n (%)** | 7 (5.5) |

[1]As made by Ballard score, if performed. If no Ballard score available, gestational age assessments were recorded based on the date of the last menstrual period, or ultrasound assessment or as per unknown method recorded in the medical record; [2]Temperature <36.5°C; [3]Blood glucose <2.6mmol/L; [4]pH <7.35

Abbreviations: IQR, Interquartile Range; CPAP, Continuous Positive Airway Pressure

**Table 2** Univariate logistic regression analyses for survival to hospital discharge of neonates diagnosed with respiratory distress syndrome at the Colonial War Memorial Hospital, Suva, 2013-2014 (n=127)

| Variable | OR (95% CI) | p value |
|---|---|---|
| **Sex** | | |
| **Female** | 1.00 | |
| **Male** | 0.89 (0.37 – 2.11) | 0.78 |
| **Place of birth** | | |
| **CWMH** | 1.00 | |
| **Other central division** | 0.11 (0.01 – 1.09) | 0.06 |
| **hospital** | 0.33 (0.02 – 5.38) | 0.43 |
| **Other** | | |
| **Ethnicity** | | |
| **Indo-Fijian** | 1.00 | |
| **Ethnic Fijian** | 0.61 (0.23 – 1.65) | 0.33 |
| **Other** | 0.40 (0.08 – 2.00) | 0.26 |
| **Increased birth weight (per 100 grams)** | 1.26 (1.13 – 1.41) | <0.01 |
| **Increased gestational age (per week)** | 1.63 (1.34 – 1.98) | <0.01 |
| **Delivery method** | | |
| **Vaginal** | 1.00 | |
| **Caesarian** | 2.83 (1.25 – 6.40) | 0.01 |
| **Multiple pregnancy** | 0.60 (0.23 – 1.60) | 0.31 |
| **Prolonged rupture of membranes** | 0.27 (0.09 – 0.83) | 0.02 |
| **Gestational diabetes** | 3.01 (0.37 – 24.76) | 0.31 |
| **Antenatal corticosteroids** | 1.23 (0.38 – 3.96) | 0.73 |
| **Increasing doses of antenatal corticosteroids** | 2.08 (0.97 – 4.48) | 0.06 |
| **One minute Apgar score** | 1.72 (1.31 – 2.25) | <0.01 |
| **Five minute Apgar score** | 1.97 (1.40 – 2.76) | <0.01 |
| **Hypothermia** | 0.74 (0.15 – 3.73) | 0.72 |
| **Hypoglycaemia** | 0.90 (0.29 – 2.80) | 0.86 |
| **Acidosis** | 0.20 (0.02 – 1.74) | 0.14 |
| **Length of hospital stay (days)** | 1.05 (1.02 – 1.08) | <0.01 |
| **Length of NICU stay (days)** | 1.02 (1.00 – 1.05) | 0.10 |
| **Supplemental oxygen** | N/A (all treated with oxygen) | |
| **Continuous positive airway pressure** | 0.47 (0.16 – 1.36) | 0.16 |

| | | |
|---|---|---|
| **Mechanical ventilation** | 0.03 (0.01 – 0.12) | <0.01 |
| **Necrotising enterocolitis** | 0.14 (0.05 – 0.41) | <0.01 |
| **Sepsis** | 0.30 (0.12 – 0.75) | 0.01 |
| **Jaundice** | 4.12 (1.63 – 10.36) | <0.01 |

**Table 3** Inpatient complications of neonates diagnosed with Respiratory Distress Syndrome at the Colonial War Memorial Hospital, Suva, 2013-2014 (n=127)

| Complication | RDS cases (n=127) |
|---|---|
| **Any, n (%)** | 116 (91.3) |
| **Pneumothorax, n (%)** | 5 (3.9) |
| **Retinopathy of prematurity, n (%)** | 3 (2.4) |
| **Bronchopulmonary dysplasia, n (%)** | 3 (2.4) |
| **Sepsis, n (%)** | 65 (51.2) |
| **Patent ductus arteriosis, n (%)** | 9 (7.1) |
| **Pneumonia, n (%)** | 8 (6.3) |
| **Pulmonary haemorrhage, n (%)** | 2 (1.6) |
| **Intraventricular haemorrhage, n (%)** | 8 (6.3) |
| **Necrotising enterocolitis, n (%)** | 19 (15.0) |
| **Meningitis, n (%)** | 8 (6.3) |
| **Seizures, n (%)** | 10 (7.9) |
| **Jaundice, n (%)** | 70 (55.1) |
| **Hypoglycaemia (blood glucose <2.6mmol/L), n (%)** | 3 (2.4) |
| **Urinary tract infection, n (%)** | 9 (7.1) |
| **Disseminated intravascular coagulation, n (%)** | 3 (2.4) |
| **Apnoea of prematurity, n (%)** | 4 (3.2) |
| **Anaemia, n (%)** | 9 (7.1) |
| **Renal impairment, n (%)** | 3 (2.4) |
| **Death, n (%)** | 36 (28.4) |